8 degrees C of Greenland warming? Ice cores and ice sheet loss during the Last Interglacial

Supervisors

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Host Institution: British Antarctic Survey

Project description

During the Last Interglacial (LIG) period (130,000 to 115,000 years ago) the Arctic climate was warmer than today, and global mean sea level was probably more that 7.7m higher. The LIG sea level high stand was mainly driven by ice sheet loss. Whilst a large portion of the ice loss was from Greenland, the actual volume remains very uncertain. The most recent estimates suggest values of: +1 m (global sea level equivalent); +1.5 m; +2.1 m (Helsen *et al.,* 2013); up to about +3.8 m. The studentship will address this major source of uncertainty, thereby also helping to assess the sensitivity of the Greenland and Antarctic ice sheets to future anthropogenic warming.

Greenland Last Interglacial ice sheet loss is primarily a function of temperature, particularly summer temperature. Recent water isotope measurements of the new NEEM Greenland ice core allow the quantitative reconstruction of temperature during the LIG (Figure 1). Four other ice cores also contain partial LIG records (Sime *et al.*, 2013). NEEM community members (2013) indicate that a LIG Greenland warming of +8^{o}C, relative to the past millennium, is the most likely scenario (Figure 1). However, Helsen *et al.* (2013) show that a +8C warming cannot be reconciled with any LIG model of the Greenland ice sheet which features a reasonable ice volume. The student will aim to reconcile this disagreement.

The approach to be used is general circulation climate modelling, with embedded water isotope code. This type of numerical modelling can enable the accurate reconstruction of temperature based on ice core water isotopes measurements (Sime *et al.,* 2013). The student will build on Last Interglacial HadCM3 climate model simulations performed by Dr. Joy Singarayer and Prof. Paul Valdes in 2011. The impact of Greenland ice sheet changes on isotopic simulations will be tested by modifying the LIG Greenland ice sheet in HadCM3 using a range of morphologies (see Figure 2). HadCM3 stable water isotopic code, written by Dr. Julia Tindall, will enable the student to perform direct ice core data-model evaluation of their new LIG simulations. The project is likely to provide the student opportunity to submit manuscripts to high impact journals such as Nature or Science.

Figure 1 Reconstruction of the temperature and Greenland NEEM ice core elevation history through the Last Interglacial based on stable water isotopes (18Oice) and air content records. a, Measured 18Oice record (black). The Last Interglacial change of temperature--reconstructed from the observed 18Oice --is shown as a red curve using the red axis. b, Air content (black). Changes in the air content are caused by pressure changes due to

changing surface elevation. This can used to help reconstruct past site elevation. c, When corrected for upstream flow (cyan) and summer insolation changes (green), the air content curve can be 'translated' to elevation changes (blue). From NEEM community members (2013).

Figure 2 Simulated range from selected experiments for the minimum Greenland ice sheet geometry during the Last Interglacial. Panel a, extent of the Greenland ice sheet for the maximum contribution to Lasst Interglacial sea level change (+3.8 m), b, the extent of the most likely contribution (+1.5 m), c, the extent of the minimum contribution (+0.4 m) and d, minimum extent for the most likely model ensemble member (+1.5 m). Red spots show Greenland ice core locations. From Stone et al. (2013).

References: Helsen *et al.* Coupled regional climate-ice-sheet simulation shows limited Greenland ice loss during the Eemian, *Clim. Past,* 9,(2013).NEEM community members, Eemian interglacial reconstructed from a Greenland folded ice core, *Nature,* 493, (2013*).* Sime *et al.* Warm climate isotopic simulations: what do we learn about interglacial signals in Greenland ice cores? *Quat. Sci. Revs.* 67, (2013).

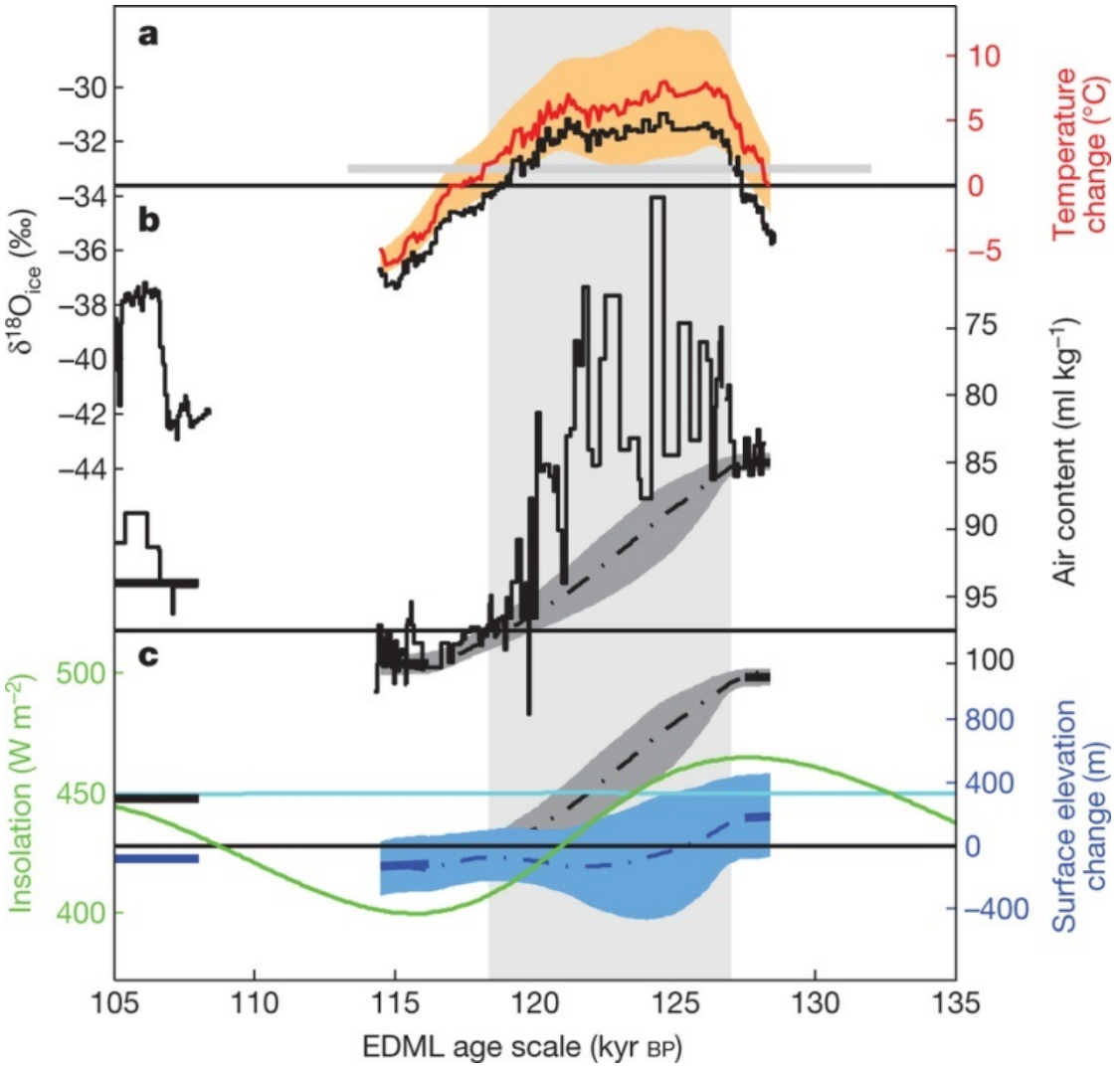
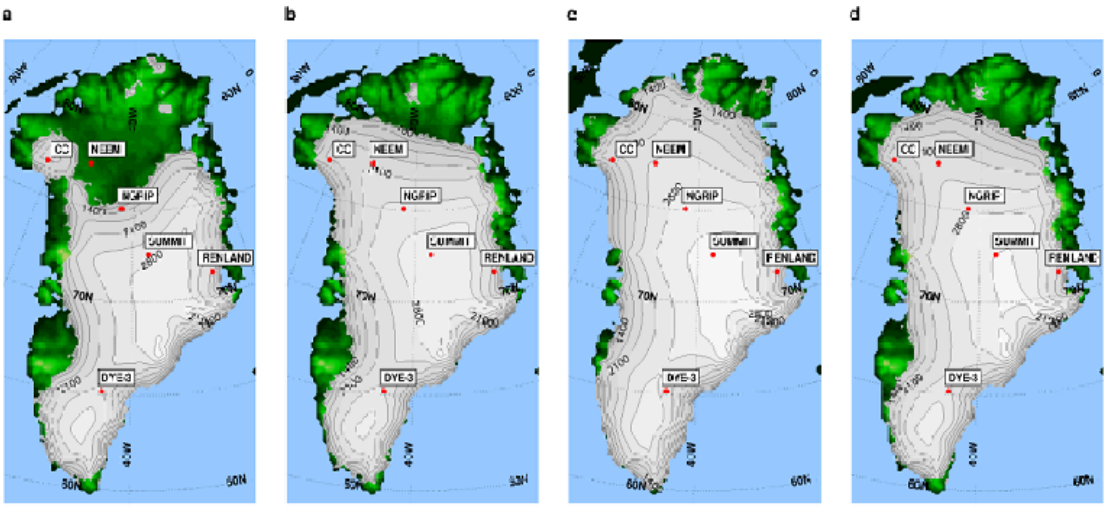


Figure 1


a
b
c
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CC
NEEM
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Figure 2